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HEIGHTS AND WEIGHTS OF SCHOOL CHILDREN.

A Study of the Heights and Weights of 14,335 Native White School Children in Maryland, Virginia, and North and South Carolina.[1]

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INTRODUCTORY.

A number of so-called standards of the physical development of children are in more or less general use in this country, largely for determining the state of nutrition. For the most part these standards represent averages of measurements made by different observers in widely separated communities, without reference to racial stock or geographical distribution. For purposes of comparison and in order to present anthropometrical observations for groups that are fairly homogeneous with respect to race stock and geographic location in the United States, selections of records were made from a considerably larger amount of material collected in a series of field investigations in child hygiene by Public Health Service officers during the last six years.

The present study deals with 14,335 white children of native parentage in representative localities in Maryland, Virginia, and North and South Carolina. The observations are confined to children actually attending school, ranging in age from 6 to 16 years, inclusive. While in every case a somewhat intensive physical examination (and for a considerable proportion, mental examination) was made, all children regardless of their physical or mental status, were included. The observations, therefore, may be said to be of a typical school population within the racial and geographical limits mentioned; they include the handicapped individuals, as far as handicapped individuals were found attending school, as well as the probable normal.

A considerable variety of anthropometrical records was collected for each individual in addition to records of physical defects and mental status. The present study, however, is confined to observations

[1] From Field Investigations in Child Hygiene, United States Public Health Service, in cooperation with the Statistical Office, United States Public Health Service.

on standing height and weight. The presentation of the other data is reserved for later publications.

SCOPE OF THE STUDY.

A statistical study of the height and weight records of the 14,335 children was made along the following lines:

1. A series of comparisons of the mean heights and weights at different ages for the two sexes for the purposes (*a*) of discovering such differences as might exist at various ages between boys and girls with respect to height, weight, and the relation of weight to height; and (*b*) of observing the rates of growth in these respects during the period of 6–16 years.

2. The degree of variation in heights and weights at each age for either sex in terms of the standard deviation and the coefficient of variability.

3. The degree of correlation between the heights and weights of individuals of either sex at each age, using the correlation coefficient and ratio and regression coefficient as expressions of the relation.

4. The construction of a table of heights and weights according to single years of age for boys and for girls of the particular racial group and geographical section selected.

The detailed data and certain statistical constants derived therefrom are presented for reference in appended tables.

GENERAL CONSIDERATIONS.

Residential distribution.—The school children here considered were from various rural districts, small towns, and cities of moderate size in the four States mentioned. Their distribution according to locality is shown in Table I.

TABLE I.—*Distribution of 14,335 children observed for height and weight according to locality of residence.*

Name of locality.	Nature of locality with approximate population of urban localities.	Number of children observed.
Frederick County, Md.	Rural, village, and Frederick, town (10,000).	4,348
Petersburg, Va.	City (30,000)	1,748
Hampton, Va.	Town (6,000)	1,153
Charlotte, N. C.	City (45,000)	3,822
Spartanburg, S. C.	City (20,000) and near-by mill villages	2,562
Greenville, S. C.	City (20,000)	702

It is believed that these localities are fairly representative of the section included within the four States. As mentioned above, in order to exclude differences in race stock as far as possible, except in so far as native-born persons in this section are affected by them, the 14,335 individuals selected are of native-born white parentage.

Sex and age distribution.—The sex and age distribution of the children are shown in Table II.

TABLE II.—*Distribution according to sex and age of 14,335 native white children observed for weight and height in certain localities in Maryland, Virginia, North and South Carolina.*

Age at nearest birthday (years).	Number.		Per cent.	
	Boys.	Girls.	Boys.	Girls.
All ages	7,132	7,203	100.0	100.0
6	380	353	5.3	4.9
7	745	735	10.4	10.2
8	904	854	12.7	11.9
9	889	900	12.5	12.5
10	973	936	13.6	13.0
11	871	847	12.2	11.8
12	781	805	11.0	11.2
13	679	695	9.5	9.6
14	471	528	6.6	7.3
15	278	331	3.9	4.6
16	161	219	2.3	3.0

The age at nearest birthday is employed in this study.

The distribution according to age is quite similar for the two sexes, although, as was expected, a slight preponderance of girls is to be noted at the ages 14 to 16, inclusive, because of the greater tendency on the part of older boys to quit school.

For both sexes the numbers observed at the ages of 6 to 14, inclusive, are sufficiently large to constitute reasonably fair samples of the population of this section. Less dependence can be placed on the representativeness of the data for the ages 15 and 16 because of the relatively small numbers of children comprising these age groups. This should be borne in mind when certain irregularities appear in the analysis which seem to be peculiar to the ages named.[2]

I. Mean Heights and Weights.

The measurements of children considered in this study were all made by medical officers of the United States Public Health Service in the schools of the various localities included. The children were measured as they were dressed, and in shoes except when the child was attending school barefooted. Weights were taken with wraps and heavy coats removed, leaving only the ordinary indoor clothing.

The measurements are so classified that the mid-points of unit classes fall on the even inch and the even pound.

MEAN HEIGHTS AND WEIGHTS OF BOYS AND GIRLS AT DIFFERENT AGES.

The basis for the first series of comparisons is given in the table of mean (arithmetic average) heights and weights [3] (Table III).

[2] The probable errors of the mean heights and weights at each age are given in appendix, Table XXI.

[3] The mean rather than the median or modal heights and weights have been used for the reason that the means appear to be satisfactory expressions. The modes are difficult to define in some instances because of somewhat irregular distributions due to small numbers. The medians are in all instances somewhat lower than the means, but their variations are similar in all essential respects to those of the means. (See appendix, Table XXI.) Furthermore, the means are more useful in comparing our results with those of other studies, and are more desirable in expressing degrees of dispersion and correlation.

TABLE III.—*Mean heights and weights of 14,335 native white children in Maryland, Virginia, North and South Carolina, at each age, compared for boys and girls.*[1]

Age at nearest birthday (years).	Height (inches).		Weight (pounds).	
	Boys.	Girls.	Boys.	Girls.
6	45.4	44.8	47.5	45.5
7	46.8	46.6	50.4	48.3
8	48.8	48.5	54.5	52.4
9	50.7	50.5	59.6	58.0
10	52.6	52.5	65.2	64.0
11	54.3	54.5	71.1	70.3
12	56.2	57.0	78.0	79.7
13	58.0	59.3	85.1	89.7
14	60.3	61.1	95.4	99.4
15	62.9	62.5	108.4	107.6
16	64.6	63.3	116.7	113.6

[1] Probable errors of the means are shown in appendix, Table XXI.

The differences between the means for boys and girls at a given age period are not great, but they are significant. Table IV, showing the differences, will assist in making the comparison from this point of view:

TABLE IV.—*Comparison of the mean heights and weights (as given in Table III), showing the excess in favor of either sex at different ages.*

Age at nearest birthday (years).	Excess in the mean—			
	Height of—		Weight of—	
	Boys over girls (inches).	Girls over boys (inches).	Boys over girls (pounds).	Girls over boys (pounds).
6	0.6	.....	2.0	.....
7	.2	.....	2.1	.....
8	.3	.....	2.1	.....
9	.2	.....	1.6	.....
10	.1	.....	1.2	.....
11	.....	0.2	8	.....
12	.....	.8	.....	1.7
13	.....	1.3	.....	4.6
14	.....	.8	.....	4.0
15	.4	.....	.8	.....
16	1.3	.....	3.1	.....

It will be noted in the group studied that on the average at the ages of 11 to 14, school girls are taller than school boys, and that at the ages of 12 to 14 the girls are also heavier. This observation merely corroborates for the particular racial and geographic group under consideration what has been found by other observers to be uniformly true during the period of puberty.

WEIGHT-HEIGHT INDEX.

The relation of weight to height, commonly expressed in the form of the ratio of weight to height at each age and called the weight-height index, is shown in Table V.

TABLE V.—*Weight-height indices, or the ratios of mean weight to mean height, at each age for 14,335 native white children in Maryland, Virginia, North and South Carolina, compared for boys and girls.*

Age at nearest birthday (years).	Mean weight in pounds / Mean height in inches	
	Boys.	Girls.
6	1.05	1.02
7	1.08	1.04
8	1.12	1.08
9	1.18	1.15
10	1.24	1.22
11	1.31	1.29
12	1.39	1.40
13	1.47	1.51
14	1.58	1.63
15	1.72	1.72
16	1.81	1.79

The differences in the indices for the sexes, it will be noted, occur at the same ages, approximately, as the differences in weights and heights considered separately. Computed from Table V, they are given for convenience in Table VI.

TABLE VI.—*Comparison of the mean weight-height index (as given in Table V) showing the excess in favor of either sex at different ages.*

Age at nearest birthday (years.)	Excess in the mean weight-height index (pounds per inch of height).	
	Boys over girls.	Girls over boys.
6	0.03	.....
7	.04	.....
8	.04	.....
9	.03	.....
10	.02	.....
11	.02	.....
12	.....	0.01
13	.....	.04
14	.....	.05
15	.....	.....
16	.02	.....

Here, again, it is found that the results correspond in a general way to those of similar studies of other groups of children. The boys are heavier than the girls for each inch of height at the ages of 6 to 11, both inclusive, and at 16. At the ages 12 to 14 the girls weigh more than the boys, and at 15 no difference appears for this group of children.

RATE OF INCREASE IN HEIGHT AND WEIGHT.

The series of means given in Tables III and V suggest an interpretation from the point of view of development; and considered in this light, although constituting observations of different individuals

at each age, they approximate the records of growth of the same individuals.

The rate of increase in height and weight or in the weight-height index is not easily seen from the tables of means and ratios. Per-

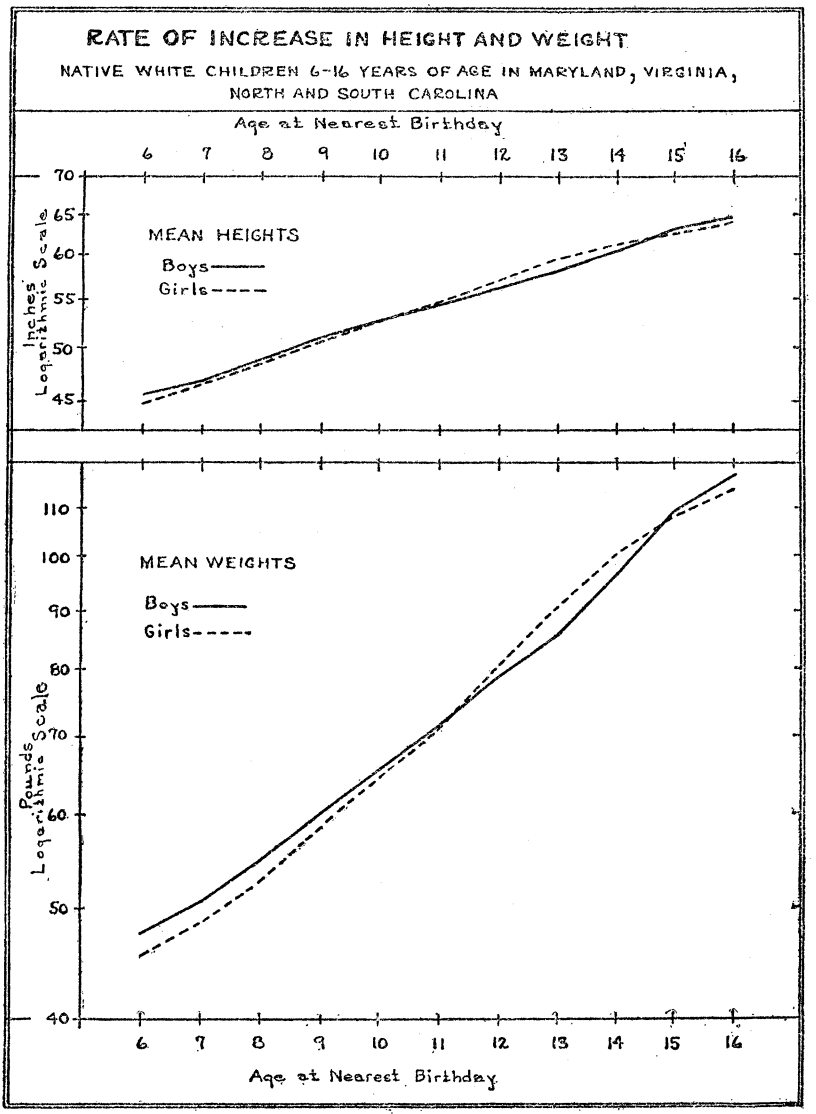


FIG. 1.

haps the quickest and simplest way to show it is to plot them on a logarithmic vertical scale. The means in Table III have been plotted in Figure 1.[4]

[4] In constructing the vertical scales for height and weight the spacing has been so arranged as to allow approximately the same space for an inch of height as for a pound in weight. The horizontal scales correspond exactly. The *slope* of the four lines, therefore, is comparable.

The curves also illustrate graphically the comparison of the actual mean heights and weights of boys and girls at different ages.

If the mean heights or weights fall in an absolutely straight line on a logarithmic scale (the scale being so constructed as to give the same results had the logarithms of the means been plotted on ordinary cross-section paper), obviously the rate of increase is unchanging. There are, however, quite definite curves in the lines connecting the points, indicating as other investigators have pointed out, that the rate of increase in either height or weight varies at different ages for both boys and girls. The rate of increase in the height of boys shows a tendency to slacken between the ages of 11 and 13; and the same slackening is seen for girls, but not until the age of 13. The mean weights of boys show an accelerating rate of increase until the age of 15, with a marked impetus at the age of 13. For girls the weight curve rises more rapidly than for boys up to the age of 13, where the slackened rate of increase begins and continues through the last year of age (16) for which data are available.

These variations in the rate of increase are expressed numerically in Table VII.

TABLE VII.—*Percentages of annual increase in mean height and mean weight of 14,335 native white children in Maryland, Virginia, North and South Carolina, compared for boys and girls.*

Age period.	Percentage increase in—			
	Height.		Weight.	
	Boys.	Girls.	Boys.	Girls.
6 to 7 [1]	4.0	4.1	6.1	6.2
7 to 8	3.9	3.9	8.1	8.5
8 to 9	3.9	4.4	9.4	10.7
9 to 10	3.8	3.8	9.4	10.3
10 to 11	3.1	3.9	9.0	9.8
11 to 12	3.4	5.2	9.7	13.4
12 to 13	3.4	4.2	9.1	12.5
13 to 14	4.0	2.9	12.1	10.8
14 to 15	4.7	2.0	13.6	8.2
15 to 16	3.0	1.5	7.7	5.6

[1] All ages are those at nearest birthday.

The relatively faster increase in weight than in height suggests, of course, that the weight-height index increases as children grow older. The curves constructed by plotting the weight-height indices in Table V on a logarithmic scale are shown in Figure 2.

Beginning at about 8 years of age the rate of increase in the weight-height index is markedly slower for boys than for girls up to the age of 13 or 14. Thereafter the opposite is true.

The means given in Table V may be used in still another way in considering the question of growth in weight in relation to height.

If the annual increment in weight be divided by the annual increment in height for the corresponding year of age, we will obtain a series of figures showing the annual increase in weight per each inch of increase in height. Table VIII presents the annual increments computed from the means given in Table III and the ratios found in the manner suggested.

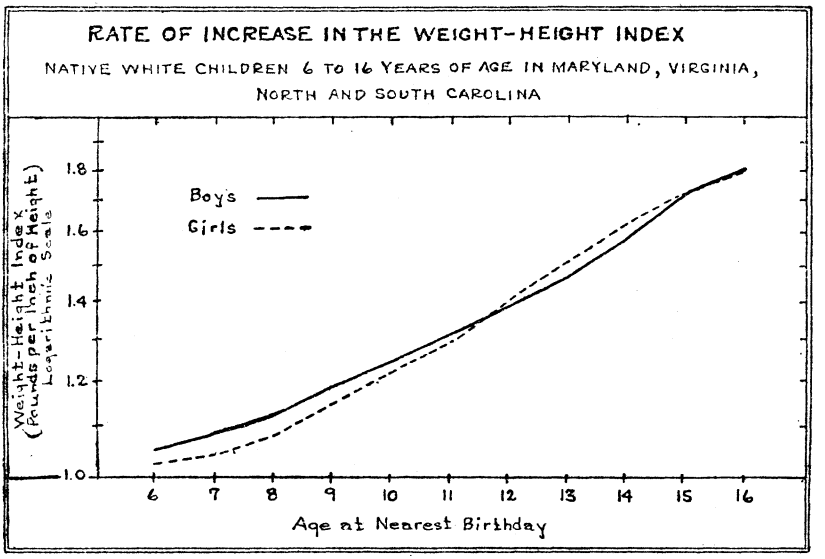


Fig. 2.

TABLE VIII.—*Annual increments in pounds of weight for each inch of increment in height computed from mean weights and heights of 14,335 native white children in Maryland, Virginia, North Carolina, and South Carolina, compared for boys and girls.*

Age period.	Annual increment.				Annual increment in weight (pounds) for each inch of increment in height.	
	For boys.		For girls.			
	In height (inches).	In weight (pounds).	In height (inches).	In weight (pounds).	Boys.	Girls.
6 to 7 [1]	1.4	2.9	1.8	2.8	2.1	1.6
7 to 8	2.0	4.1	1.9	4.1	2.1	2.2
8 to 9	1.9	5.1	2.0	5.6	2.7	2.8
9 to 10	1.9	5.6	2.0	6.0	2.9	3.0
10 to 11	1.7	5.9	2.0	6.3	3.5	3.2
11 to 12	1.9	6.9	2.5	9.4	3.6	3.8
12 to 13	1.8	7.1	2.3	10.0	3.9	4.3
13 to 14	2.3	10.3	1.8	9.7	4.5	5.4
14 to 15	2.6	13.0	1.4	8.2	5.0	5.9
15 to 16	1.7	8.3	.8	6.0	4.9	7.5

[1] All ages are those at nearest birthday.

The ratios in the two last columns, when considered as two series, merely indicate in another way the differences in the direction of growth of boys and girls. They have been plotted on a logarithmic scale in Figure 3.

The gain in weight by girls for each inch of gain in height increases at an almost constant rate from 7 to 16 years. Allowing for certain irregularities in the data, the gain in weight by boys for each inch of gain in height is practically the same as that by girls up to the age of 11, and thereafter is at a considerably slower rate.

COMPARISON OF MEASUREMENTS OF INDIVIDUALS OF DIFFERENT AGES WITH PERIODIC MEASUREMENTS OF A SINGLE GROUP OF INDIVIDUALS.

A number of observers have objected to height and weight standards based on measurements of children taken in cross section, at

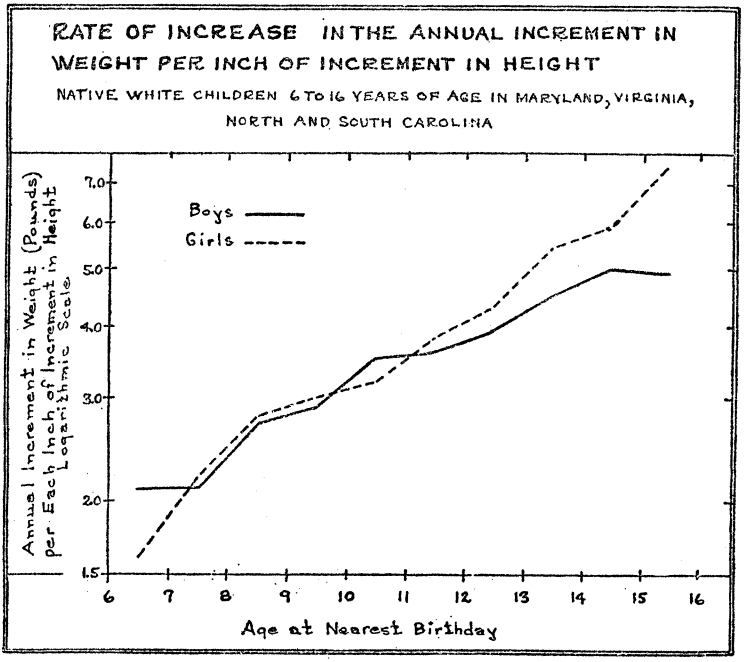


Fig. 3.

different age periods, on the ground that such measurements do not furnish an accurate index of the rate of growth. It has been suggested that such an index can be determined with appreciable accuracy only by making periodic measurements of the same children over a number of years. On the other hand, an index determined by periodic measurements requires time, while the need for fairly reliable standards by which to gauge the state of nutrition is pressingly present. Furthermore, such a group of children, of necessity, will be a selected group which finally, through process of elimination, is likely to be composed of a relatively small number of the surviving fittest who are benefited by special contact with health educational methods. There is the danger, therefore, that the end results will not be applicable for comparison with children not subjected to special influences, and with children of other sections of the country.

Although the measurements made by the United States Public Health Service constitute observations of different groups of individuals at each age, they may be compared with successive observations of a single group of individuals. Using the records recently published by Prof. B. T. Baldwin, the following comparison is afforded.[5]

TABLE VIII-A.—*Mean heights, mean weights, and mean weight-height indices of children of different ages measured by the United States Public Health Service, compared with corresponding measurements made periodically on a single group of children by Dr. B. T. Baldwin.*

Age at nearest birthday.	Height (inches).				Weight (pounds).				Weight-height index (pounds).			
	Boys.		Girls.		Boys.		Girls.		Boys.		Girls.	
	U. S. P. H. S.	Baldwin.	U. S. P. H. S.	Baldwin.	U. S. P. H. S.	Baldwin.	U. S. P. H. S.	Baldwin.	U. S. P. H. S.	Baldwin.	U. S. P. H. S.	Baldwin.
6	45.4	45.4	44.8	44.3	47.5	45.2	45.5	42.6	1.05	0.99	1.02	0.96
7	46.8	47.8	46.6	46.8	50.4	50.6	48.3	48.0	1.08	1.05	1.04	1.02
8	48.8	49.8	48.5	49.1	54.5	55.3	52.4	53.8	1.12	1.11	1.08	1.09
9	50.7	51.5	50.5	51.1	59.6	60.7	58.0	59.7	1.18	1.17	1.15	1.16
10	52.6	53.5	52.5	53.1	65.2	67.2	64.0	67.2	1.24	1.25	1.22	1.26
11	54.3	55.3	54.5	55.3	71.1	73.1	70.3	74.1	1.31	1.32	1.29	1.33
12	56.2	56.9	57.0	57.6	78.0	77.7	79.7	83.9	1.39	1.36	1.40	1.45
13	58.0	59.3	59.3	60.1	85.1	88.4	89.7	96.2	1.47	1.49	1.51	1.60
14	60.3	61.8	61.1	61.8	95.4	98.3	99.4	107.2	1.58	1.59	1.63	1.73
15	62.9	64.1	62.5	62.7	108.4	109.4	107.6	115.5	1.72	1.70	1.72	1.84
16	64.6	66.7	63.3	63.6	116.7	120.6	113.6	120.6	1.81	1.80	1.79	1.89

In the case of the boys, the height and weight curves follow the same general trend, with Baldwin's group slightly above that of the Public Health Service at practically every age. The weight-height indices for the two groups of boys are practically the same at each age except 6 years. In the case of the girls, the heights of the two groups follow much the same course, with a slight convergence of the curves at the older ages. The weight and the weight-height index curves for the girls show a tendency to diverge after 7 years of age, and the divergence is considerable by the age of 16. Some factor evidently influenced the growth of the girls measured periodically which failed to influence the girls measured by the United States Public Health Service. Otherwise the curves appear to be as similar as could be expected.

II. Difference in Heights and Weights of Children of the Same Sex and Age.

Thus far comparisons in this study have been made of average (mean) heights and weights, but at each age children differ considerably in these respects and the differences are greater at some ages than at others. The averages which have been studied do not take into account these differences because the average (arithmetic

[5] Physical Growth of Children from Birth to Maturity. By Bird T. Baldwin, University of Iowa Studies in Child Welfare, 1921. Baldwin's figures are based on semiannual measurements of an average of 125 boys and 125 girls from the Horace Mann School, Teachers' College, Columbia University, New York, for periods of 8 years or more. (P. 411.)

mean) does not show for any group of children the range of weights or heights, or the "dispersion" of weights or heights above and below the average.

The nature of these differences is shown by plotting the number of children at each height or weight. As in all biometrical distributions of this character, the distribution will be found to form a

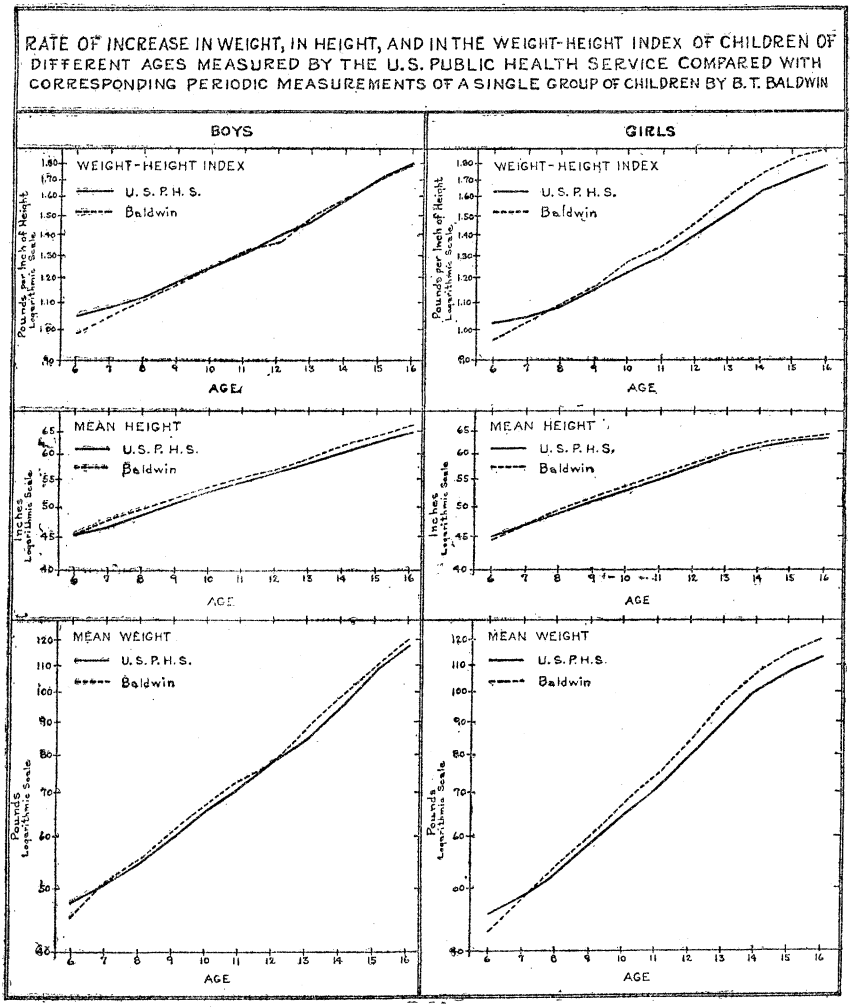
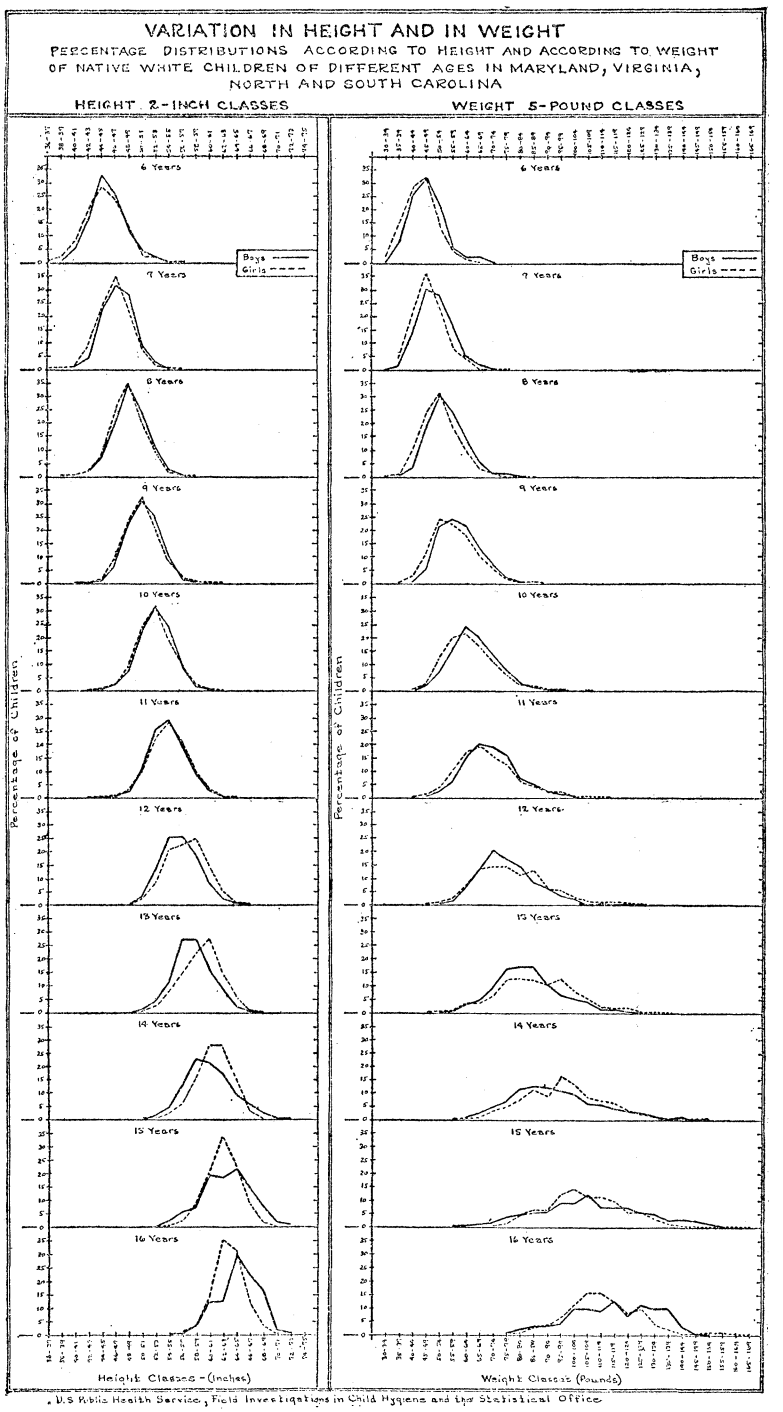


Fig. 3a.

more or less symmetrical frequency curve, which means that most of the children will tend to fall within rather narrow height or weight limits and fewer and fewer will fall in the classes toward either extreme. In plotting Figure 4, the percentages at each height or weight interval are used so as to reduce the data for the different ages to the same basis vertically.



U.S Public Health Service, Field Investigations in Child Hygiene and the Statistical Office.

Fig. 4.

The differences in the *shape* of the curves for heights as well as for weights are quite marked when ages are compared. In general, the older the age, the flatter is the curve and hence the greater the dispersion. This means that children of a given age differ more widely in height or weight as they grow older. This statement should be qualified, however, for a closer study of the graphs affords the suggestion that the greatest dispersion or difference occurs at the age of puberty. Differences of this character are exhibited by both boys and girls.

STANDARD DEVIATION IN HEIGHTS AND WEIGHTS.

A more nearly exact expression of these differences than that afforded by the graphic method is necessary. The usual statistical term used to express the degree of differences in distribution is the standard deviation (σ), which, in turn, is expressed by (V) the coefficient of variability as a percentage of the mean. As the σ or the V is large or small, so the differences in the individual heights or weights are large or small.

In Table IX are given the standard deviations in heights and weights at each age for boys and girls and the corresponding coefficients of variability.

TABLE IX.—*Variation in heights and weights of boys and girls of the same age.*

As expressed in standard deviations in standing heights and weights at each age of 14,335 native white children in Maryland, Virginia, North and South Carolina, and the corresponding coefficients of variability.

Age at nearest birthday.	Standard deviation.		Coefficient of variability.	
	Boys.	Girls.	Boys.	Girls.
	STANDING HEIGHTS.			
6	2.77±0.068	3.21±0.081	6.10	7.17
7	2.58± .045	2.53± .044	5.51	5.43
8	2.54± .040	2.47± .040	5.20	5.09
9	2.66± .043	2.69± .043	5.25	5.33
10	2.64± .040	2.83± .044	5.02	5.39
11	2.82± .046	3.00± .049	5.19	5.50
12	3.03± .052	3.02± .051	5.39	5.30
13	2.93± .054	3.16± .057	5.05	5.33
14	3.83± .084	2.99± .062	6.35	4.89
15	3.85± .110	2.62± .039	6.12	4.19
16	2.99± .112	2.50± .081	4.63	3.95
	WEIGHTS.			
6	7.76±0.190	7.27±0.185	16.34	15.98
7	6.56± .115	6.26± .110	13.02	12.96
8	7.13± .113	7.39± .121	13.08	14.10
9	7.98± .128	9.24± .147	13.39	15.93
10	9.09± .139	10.79± .168	13.94	16.86
11	10.30± .165	12.87± .211	14.49	18.31
12	12.43± .212	14.85± .250	15.94	18.63
13	12.84± .235	16.41± .297	15.09	18.29
14	17.52± .385	14.75± .303	18.36	14.84
15	20.46± .585	16.38± .429	18.87	15.22
16	17.12± .644	16.24± .523	14.67	14.26

The coefficient of variability is, of course, the best expression of the degree of variation, since it takes into account the size of the mean from which the deviations are measured. As the table and the graph (Fig. 6) clearly show, there are marked differences in this coefficient for weight at different ages for the same sex and, when the sexes are compared, for the same age. After the age of 7 the variation of weight increases with age up to 13 years for girls and 15 years for boys, and then decreases, the decrease thus beginning at an earlier age for girls than for boys.

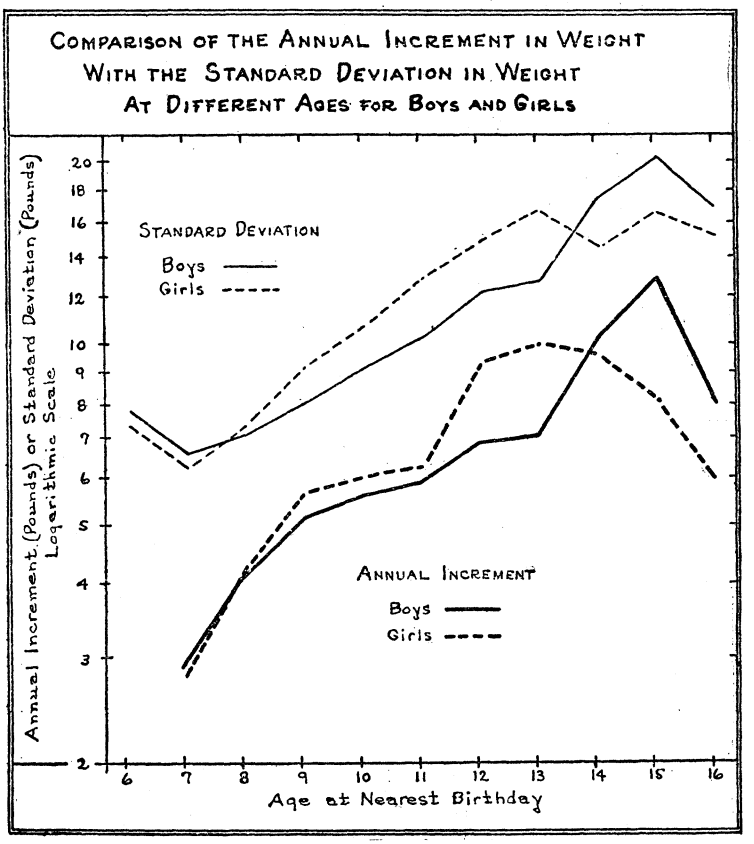


Fig. 5.

RATE OF GROWTH AND VARIATION IN WEIGHT.

It is of interest to inquire the reasons for the greater variation in weight at certain ages. While it might be due in part to a greater percentage of abnormal children at certain ages who may vary more from the mean than the normal children, the rapidity of growth as expressed by the mean annual increment in weight is definitely associated with variation in weight, as shown in Figure 5.

A comparison of the mean annual increment (see Table VIII) with the standard deviation (see Table IX) for the same sex shows this correlation in a more striking manner. The variation in weight seems to increase or decrease with the mean annual increment. That is to say, children vary most in weight at the periods of the most rapid increase in weight.

These differences from the point of view of sex are also striking. The degree of variation in weight for boys and girls of the same age

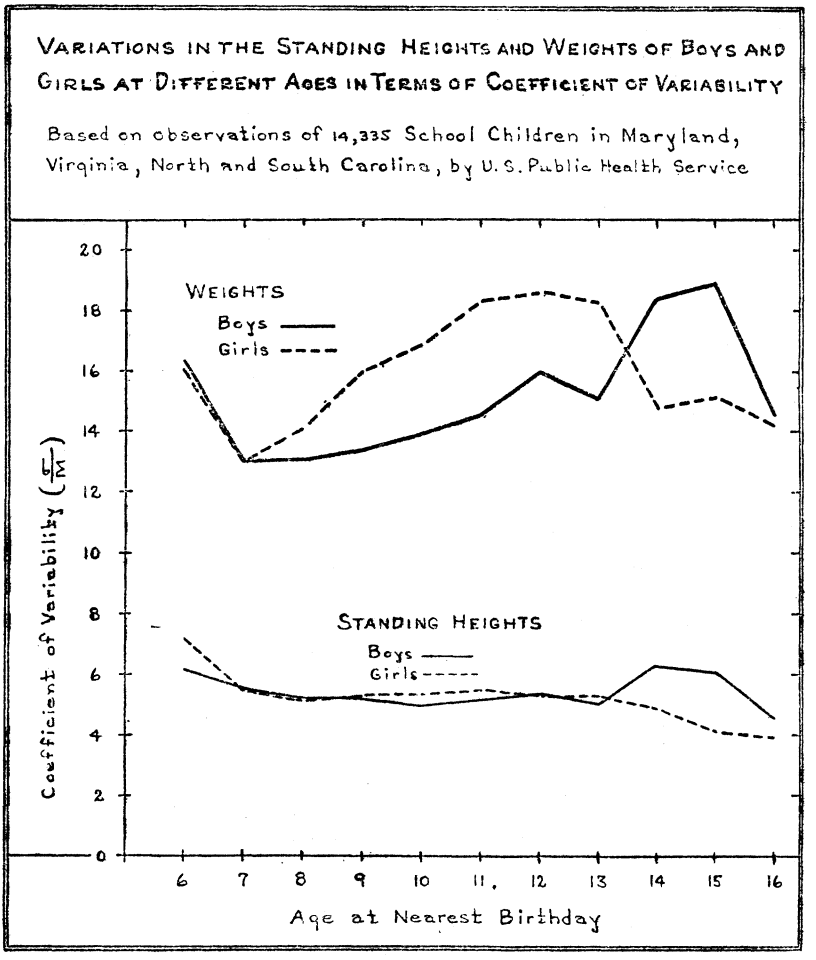


Fig. 6.

is by no means the same as the standard deviations (see Table IX and Figure 5, upper curves) clearly indicate. The same sort of differences between the sexes is shown when the annual increment in pounds is compared. (See Table VIII and Figure 5, lower curves.)

RELATION OF HEIGHT TO VARIATIONS IN WEIGHT.

In comparing the degree of variation in weights for boys and girls the factor of height must also be considered. The degree of variation

as expressed by the coefficient of variability is plotted for weights and heights for either sex in Figure 6.

Since the two sets of curves are quite different in some respects, an attempt has been made to see what the coefficients of variability in weight would be if no variation in heights had existed. This has been done by a method of averaging the coefficients of variability in weight for children of a given age at each inch of height, a method which is admittedly somewhat crude but accurate enough for the purpose in view.[6]

TABLE X.—*Variation in weights of boys and girls of the same age, after eliminating (roughly) the effect of variation in height.*

As expressed by the weighted averages of the coefficients of variability for weight at each inch of height.

Age at nearest birthday.	Averages of the coefficients of variability.	
	Boys.	Girls.
6	8.48	8.55
7	9.05	8.39
8	8.99	8.73
9	8.65	10.74
10	9.49	11.25
11	9.95	12.01
12	10.28	12.15
13	10.40	12.60
14	10.51	13.30
15	9.66	12.08
16	9.04	11.50

The results given in Table X are shown graphically in Figure 7.

It appears that girls over 8 years of age vary with respect to weight in a considerably greater degree than boys of the same age and of the same approximate height. The degree of variation is somewhat more pronounced after the age of 13.

III. Correlation of Height and Weight.

Thus far the children of given age and sex have been considered from two standpoints: First, as constituting groups, using the average (mean) heights and weights of different sex-age groups for making comparisons; and, second, as individuals, using the standard deviation and coefficient of variability as measures of variation for determining the degree individual children differ in respect of height and weight. It now remains to consider the differences occurring in individual children in each group from the point of view of the relation of variation in height to variation in weight. That is, how closely do variations in height correspond to variations in weight among children of different ages and sexes? Obviously, if there is a very close relationship, there must be a marked uniformity in the

[6] See appendix, Tables XV and XVI, for the coefficients of variability at each height. The coefficients of variability in weight of children of a given age increase little, if any, with increase in height. It therefore seemed feasible to average these coefficients for a given age group in order to get an expression of the average relative variation in weight of children of any given height for that age.

weight of children, taking height into account; if there is not a very marked relationship, children of a given height, age, and sex will differ widely in weight. The importance of this phase of the discussion does not lie so much in demonstrating the fact that a relationship of this kind exists, since in the very nature of things it must exist, as in discovering the differences in degree of correlation for the various sex and age groups.

COEFFICIENT OF CORRELATION.

A comparison of this kind would be a very detailed and difficult task if no single measure of the relationship between the degree of

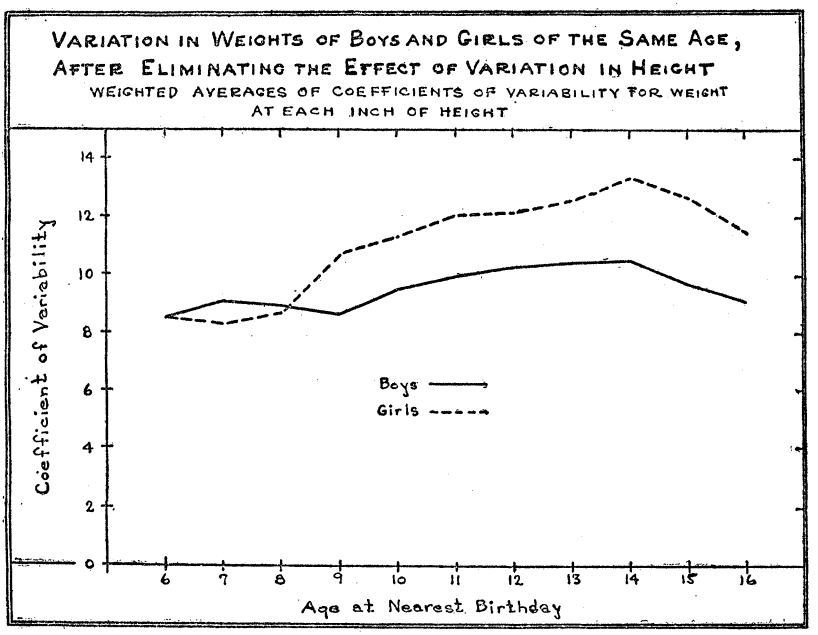


Fig. 7.

the two variations could be used. Such a statistical measure exists in the coefficient of correlation and the correlation ratio. When this coefficient or ratio is zero there is no relationship whatsoever. When it is 1, or unity, the relationship is perfect; that is, the variation in one (e. g., height) is accompanied by exactly the same variation, relatively, in the other (e. g., weight). The nearer unity, the closer the relationship between the two variables.[7]

[7] The coefficient of correlation (r) is the generally used statistical measure of linear or straight line correlation between two variables. If the items (individuals) are plotted with heights as ordinates and weights as abscissæ, and the points (or the means of the weights at the different heights) tend to fall along a straight line, the correlation is said to be linear. But if the points tend to fall along a curved line, the correlation is said to be nonlinear and, under certain conditions, the correlation ratio (η) is a better measure of the correlation between the two variables. If the ratio (η) is significantly larger than the coefficient (r), it is an indication of nonlinearity.

In the case of the heights and weights of children in this study, the differences between the correlation ratio and the coefficient are not marked except at a few ages, but in practically every instance they are found to be significant if Blakeman's criterion of nonlinearity is applied. That is, the correlation ratio is a more nearly accurate expression of correlation than the coefficient for the material used in this study.

The correlation ratios as well as the coefficients of correlation for heights and weights of boys and girls at each age are given in Table XI, together with their probable errors. (Editor's note: The correlation tables are not given here, but will be published with the reprint of this article.)

TABLE XI.—*Correlation of standing heights and weights of native white children in Maryland, Virginia, North and South Carolina.*

Age at nearest birthday.	Correlation ratio of weight on height (η).	Coefficient of correlation (r).
	BOYS.	
6	0.830±0.0108	0.782±0.0134
7	.704± .0125	.603± .0157
8	.718± .0109	.682± .0120
9	.744± .0101	.643± .0133
10	.720± .0104	.693± .0113
11	.726± .0108	.657± .0130
12	.736± .0111	.706± .0121
13	.720± .0125	.687± .0137
14	.816± .0104	.795± .0114
15	.853± .0110	.842± .0118
16	.784± .0225	.736± .0244
	GIRLS.	
6	0.788±0.0136	0.675±0.0195
7	.725± .0118	.679± .0134
8	.751± .0101	.719± .0111
9	.724± .0107	.661± .0127
10	.709± .0110	.660± .0125
11	.695± .0120	.647± .0135
12	.719± .0115	.703± .0120
13	.707± .0128	.669± .0141
14	.692± .0153	.643± .0172
15	.543± .0262	.427± .0303
16	.592± .0296	.565± .0310

As may be expected, in all instances the correlation is high and, from the point of view of the probable error, significant. The degree of correlation, however, varies considerably in the different ages and as between boys and girls. These differences are not merely accidental, but indicate definite trends. In order to visualize the differences the correlation ratios have been plotted in Figure 8.

The correlation of height and weight is quite high at 6 years of age for both boys and girls in this particular group of children. From 7 to 13 years of age the correlation for both sexes is lower and similar, although that for the girls is slightly lower after 8 years than for boys. After the age of 13 there is a marked divergence, the correlation for boys being quite high and that for girls relatively low.

Stated in other words, the weights of both boys and girls vary in pretty much the same way as do the heights in the ages under the age of 14, the taller the children the more they weigh according to a fairly constant ratio; but in the ages 14 to 16, height or weight appear to be affected to a markedly greater extent by some other factor or factors.

VARIATION IN WEIGHT PER INCH OF VARIATION IN HEIGHT.

This may be expressed more exactly by stating the variation in weight (pounds) per inch of variation in height at each age, as shown in Table XII, and graphically in Figure 9.[8]

TABLE XII.—*Variation in weight (pounds) per inch of variation in height compared for boys and girls at different ages.*

Coefficient of regression of weight on height of native white children of Maryland, Virginia, North and South Carolina by sex and age.

Age at nearest birthday.	Coefficient of regression of weight on height (pounds).	
	Boys.	Girls.
6	2.19	1.52
7	1.53	1.68
8	1.91	2.15
9	1.92	2.27
10	2.38	2.52
11	2.41	2.79
12	2.91	3.44
13	3.02	3.48
14	3.66	3.16
15	4.46	2.69
16	4.24	3.70

From 7 to 13 years, inclusive, the variation in weight per inch of variation in height was less among boys than girls; at 6, 14, 15, and 16 years of age the opposite was true.

IV. Summary.

1. The basis of this study consists of height and weight measurements of 14,335 native white school children from 6 to 16 years of age made by officers of the United States Public Health Service in representative localities of Maryland, Virginia, and North and South Carolina.

2. The mean heights of the girls 11 to 14 years of age, inclusive, and the mean weights of the girls 12 to 14 years, inclusive, are greater than those of the boys of the same ages. At the other ages studied the boys are taller and heavier than the girls. The weight-height index (weight per inch of height) of the girls exceeds that of the boys from 12 to 14 years and is equal at 15 years; at the other ages studied, it is greater for boys than for girls.

3. The annual increment in weight of the girls exceeds that of the boys from 8 to 13 years, inclusive. At the other ages studied it is greater for boys. However, when the annual increment in weight

[8] The coefficient of regression of weight on height (computed from the coefficient of correlation (r) for a given age indicates the *average* difference in weight (pounds) per inch of difference in height.

per inch of increment in height is considered, it is found greater for girls than boys at every age after 6, except 10 years.

4. Variations in height and in weight differ markedly for different sex-age groups and are closely associated with the rate of increase in weight. When variation in weight is considered independently of variation in height, the boys 14 to 16 years of age vary considerably more in weight than the girls of the same age. But when the effect of variation in height is eliminated, the girls vary more in weight than the boys of the same age at all ages above 8 years. In other

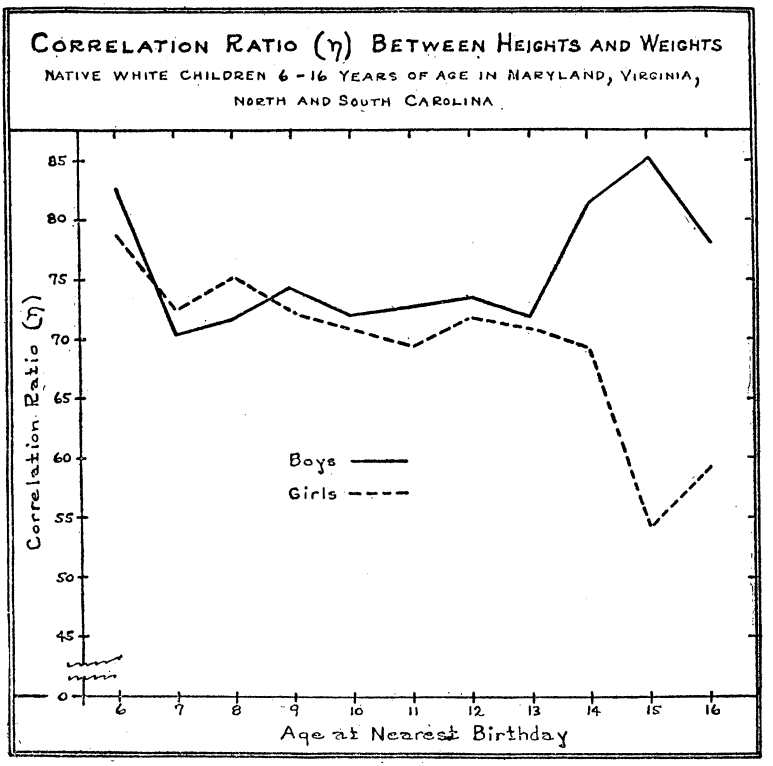


Fig. 8.

words, girls after 8 years of age vary more in weight than boys of the same age and height.

5. Correlation between heights and weights was found to be lower for the girls than for the boys at all ages above 8 years and markedly lower after 13 years of age.

V. Height-Weight Tables.

Since it appears that variability in weight differs with sex, age, and height, it seems that averages which best represent a group of children are those which take all of these factors into account. It there-

fore seemed best to present the final results of the study as average weights of boys and girls of each age, by height groups. A series of mean weights was therefore computed independently for children at each year of age and at each inch of height. In order to approximate the true average weights which would be the result of measuring an infinite number of children, it was necessary to smooth the weights computed independently. Smoothed averages were derived from data shown in the tables[9] in the appendix by a formula from the

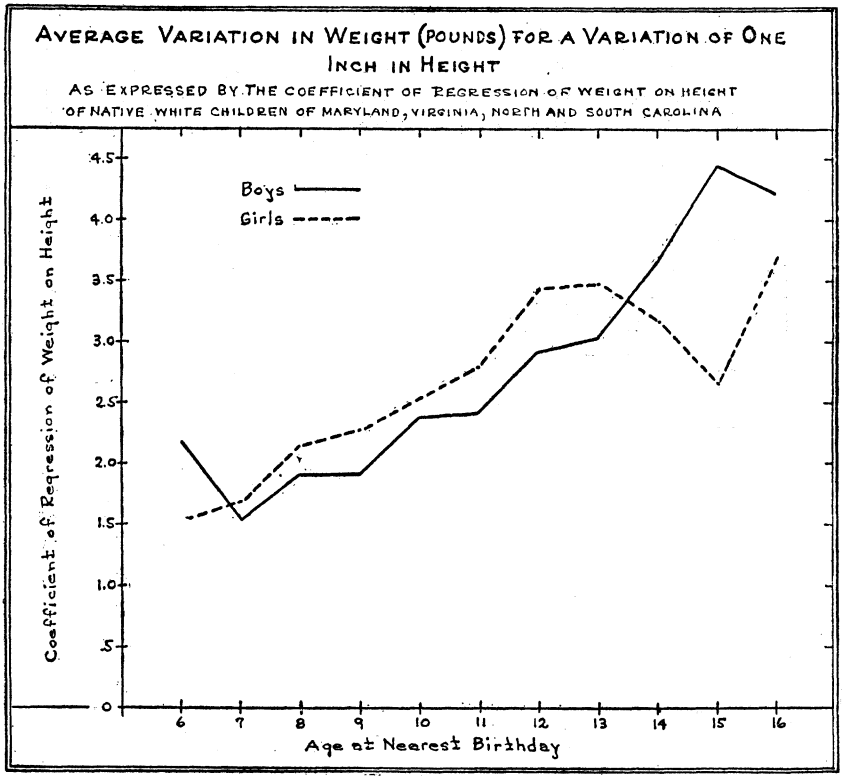


Fig. 9.

method of least squares, which give a series of weights representing the most probable smooth curve which could be constructed from the data.[10] The smoothed averages are shown in Tables XIII and XIV.

[9] The actual average weights, the standard deviations, and the coefficients of variability are given by single-year age groups and single inch-height classes in appendix Tables XV and XVI. The number of children whose measurements were considered in making up each average is also shown.

[10] Let Y=weight and X=height; then it was assumed that at any given height, X, $Y=a+bx+cx^2+dx^3$. The coefficients a, b, c, and d were evaluated by the method of least squares for each sex and age, and the smoothed weights were computed by substituting in the original equation.

TABLE XIII.—*Smoothed average weights for each inch of height of native white schoolboys in Maryland, Virginia, and North and South Carolina, ages 6 to 16 years, inclusive, for each year of age.*

Height, nearest inch.	Weight, nearest pound at each age, nearest birthday.										
	6 years.	7 years.	8 years.	9 years.	10 years.	11 years.	12 years.	13 years.	14 years.	15 years.	16 years.
41	39										
42	41										
43	43	43									
44	44	44	47								
45	46	46	48								
46	48	48	49	50	50						
47	50	50	50	51	52						
48	52	52	52	53	54	55					
49	54	54	54	55	56	57					
50	.....	56	56	57	58	59					
51	.....	59	59	60	61	61	65				
52	.....	.....	61	62	64	64	67	67			
53	.....	.....	64	65	66	67	69	69			
54	.....	.....	67	68	69	70	71	72	75		
55	.....	.....	.....	72	72	73	74	75	77		
56	.....	.....	.....	74	74	76	76	78	80		
57	.....	.....	.....	.....	77	79	80	81	83		
58	.....	.....	.....	.....	80	82	83	85	86		
59	.....	.....	.....	.....	.....	84	86	88	90	90	
60	.....	.....	.....	.....	.....	86	89	91	93	95	
61	.....	.....	.....	.....	.....	.....	92	95	97	100	
62	.....	.....	.....	.....	.....	.....	.....	99	102	104	104
63	.....	.....	.....	.....	.....	.....	.....	103	106	109	109
64	.....	.....	.....	.....	.....	.....	.....	107	111	113	114
65	.....	.....	.....	.....	.....	.....	.....	.....	116	118	118
66	.....	.....	.....	.....	.....	.....	.....	.....	121	124	124
67	.....	.....	.....	.....	.....	.....	.....	.....	.....	130	130
68	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	136

TABLE XIV.—*Smoothed average weights for each inch of height of native white schoolgirls in Maryland, Virginia, and North and South Carolina, ages 6 to 16 years, inclusive, for each year of age.*

Height, nearest inch.	Weight, nearest pound at each age, nearest birthday.										
	6 years.	7 years.	8 years.	9 years.	10 years.	11 years.	12 years.	13 years.	14 years.	15 years.	16 years.
39	38										
40	39										
41	40										
42	41	42									
43	42	42	42								
44	43	43	43								
45	45	45	45								
46	47	47	47	47	47						
47	49	49	49	49	49						
48	51	51	51	52	52	52					
49	53	53	54	54	55	55					
50	.....	55	56	56	57	58					
51	.....	57	58	59	60	60	62				
52	.....	58	60	61	62	63	64				
53	.....	.....	61	64	65	65	66	69			
54	.....	.....	.....	67	68	68	69	70			
55	.....	.....	.....	71	71	71	72	73			
56	.....	.....	.....	73	73	74	75	76	81		
57	.....	.....	.....	.....	76	77	79	79	84	89	
58	.....	.....	.....	.....	79	81	83	83	87	92	
59	.....	.....	.....	.....	.....	85	87	88	91	95	
60	.....	.....	.....	.....	.....	90	90	92	95	99	103
61	.....	.....	.....	.....	.....	.....	94	96	99	102	106
62	.....	.....	.....	.....	.....	.....	98	100	103	105	109
63	.....	.....	.....	.....	.....	.....	101	104	107	108	112
64	.....	.....	.....	.....	.....	.....	.....	108	110	112	115
65	.....	.....	.....	.....	.....	.....	.....	110	114	115	119
66	.....	.....	.....	.....	.....	.....	.....	.....	116	119	125
67	.....	.....	.....	.....	.....	.....	.....	.....	.....	122	

No attempt was made to carry the smoothed mean weight series to the extreme limits of heights. In the first place reliable averages could not be computed because of the relatively small number of children observed. In the second place averages would probably not be good criteria of the correct weights of extremely short or extremely tall children, inasmuch as those who vary so widely in height from the mean could not be assumed to conform to any computed or assumed mean weights. It is not claimed, however, that this table reaches the limits of normality, especially in the older ages; but it appeared better to keep within safe limits where the data could be relied upon than to try to make a complete table if it were necessary to use unreliable figures for the extremes.

It is suggested that this table, which is based on measurements of native white children in four representative Southern States, might serve as a table of correct weights among such children of the South. The usual tables of this sort are based on measurements of children of various racial stocks or distinctly selected groups of children, and it would seem that a table, based on measurements of children of a single race stock from one section of the country, would better represent the white children of that section. It should be borne in mind, however, that the older ages, particularly the 16-year-old boys, probably are not representative, because of the small number considered and selection due to children dropping out of school.

THE PANAMA CANAL RAT GUARD.

By W. C. Rucker, Surgeon, United States Public Health Service; Chief Quarantine Officer, Panama Canal.

The world diffusion of plague and the ever present danger from rats being carried from port to port by ships constitute a serious health hazard at the Panama Canal. Every possible precaution is therefore taken to prevent the embarkation and disembarkation of rats in Canal Zone ports, and the rat-guarding of ships thus becomes a matter of very considerable importance. To meet a need in this regard, with respect to one route of communication between shore and shipboard, there has been developed an extremely efficient and practical rat guard for ships' lines. Many of its features are not new and are simply improvements and adaptations of the best features of other forms of guards.

SPECIAL FEATURES.

The rigidity of the Panama Canal rat guard is insured by the straps, which are riveted to it. These turn sharply at right angles and hold the guard perpendicular to the line. They are riveted to half-cones, which permit the guard to fit any line accurately. The lashing is a permanent part of the guard. The guard is painted to